A REVISED TRADITIONAL/DESCRIPTIVE CLASSIFICATION OF FRUITS FOR USE IN FLORISTICS AND TEACHING.[1]

Walter S. Judd
Department of Botany, Uiversity of Florida
Gainesville, FL 32611

Summary

A revision of the traditional/descriptive classification of fruits is presented in order to reflect more accurately the great morphological diversity of tropical fruits. This is accomplished not only by broadening the definition of some terms, *e. g.*, berry, drupe, capsule, schizocarp, achene, but also by the addition of a few distinctive fruit types, *e. g.*, indehiscent pod, dehiscent drupe, and early-dehiscent fruit.

Introduction

The great diversity of size, form, texture and anatomy of fruits has long confounded plant morphologists, reproductive biologists, and taxonomists, as clearly can be seen in the broad array of fruit classifications (Baumann-Bodenheim, 1954; Egler, 1943; Gray, 1877; Janchen, 1949; Kaden and Kirpicnikow, 1965; Lawrence, 1951; Levina, 1961; van der Pijl, 1972; Radford *et al.*, 1974; Rendle, 1930; Stopp, 1950; and Winkler, 1939. For various reasons these classifications have been only partly successful. Some of the problems of fruit classification are briefly discussed below, and a practical system for floristic or teaching purposes is presented.

All systems of fruit classification must deal with several serious difficulties. First, and foremost, is the problem of the bewildering and often continuous variation of fruit structure. In fact, Van der Pijl (1972; p. 17) concluded that "the fruit is too versatile and has too many aspects to be divided into strict categories." However, many workers have attempted to impose inadequate and rigid systems with mutually exclusive categories which fail to recognize the intermediate types (see Sattler, 1966). Thus if the fruit of *Prunus* or *Nectandra* is a drupe (*i. e.*, fleshy, single "stone"), and that of *Vaccinium* or *Solanum* a berry (*i. e.*, fleshy, many seeded), what is the fruit of *Ilex*, *Clerodendrum*, *Psychotria*, or *Cordia* (*i. e.*, fleshy, several stones)? The results have often been artificial and inconsistent classifications which are not universally valid, or even useful. Additional complexities are added by the extensive parallel/convergent evolution of fruiting structures; functionally similar

---

[1] This paper is Florida Agricultural Experiment Station Journal Series No. 4981.

fruits have arisen independently in different lineages of angiosperms from similar and different gynoecial conditions. Even other parts of the flower (or associated vegetative structures) -- in addition to the matured pistil -- may form a functional part of the fruit. However, the distinction between "accessory fruits" and fruits derived only from gynoecial tissues frequently becomes blurred. Certainly no useful distinction can be made when (fleshy to dry) accessory structures are completely fused to ovarian tissue as in those fruits derived from flowers with an inferior ovary, *e. g.*, the berries of *Opuntia*, *Hamelia*, *Eugenia*, *Musa*, or *Vaccinium*, the capsules of *Lachnanthes* or *Couroupita*, the achenes of *Bidens*, the pomes of *Pyrus*, or the drupes of *Scaevola* or *Terminalia*. This extensive homoplasy has lead to the frequent comparison of non-homologous structures and confusion in phylogenetic investigations. A third major problem with many fruit classifications concerns their temperate (*i. e.*, European and North American) bias, with an undue stress on pericarp fruits. Many only slightly distinctive temperate fruit forms are given names (*e. g.*, silique vs. silicle) while many more distinctive tropical fruits are ignored (see van der Pijl, 1972). For example, what is the fruit type of *Adansonia*, *Crescentia*, *Kigelia* (indehiscent, ± dry, many seeded), *Aegle*, *Durio*, *Theobroma* (indehiscent, outer portion ± hard, fleshy within, many seeded), *Akebia*, *Tabernaemontata* (fleshy follicle), *Carya*, *Rhamnus* (some) (dehiscent drupe), *Caulophyllum* (early-dehiscent), *Heliconia* (splitting into one-seeded drupe-like segments), *Ilex*, *Cordia* (indehiscent, fleshy, with several stones), *Litchi*, *Nephelium* (indehiscent, fleshy, arilloid, one-seeded), *Momordica* (fleshy capsule), *Persea americana* (indehiscent, fleshy, one-seeded), *Sterculia* (carpels early separating into follicle-like units), *Tamarindus* (indehiscent, fleshy, several seeded "legume"), to name only a few? This temperate bias has hampered the teaching of systematics in tropical regions, and has lead to an incomplete appreciation of the diversity of tropical groups. Consider the various of fruit forms summarized by the term legume in the tropical Fabaceae.

In working throught the problems alluded to above, morphologists and taxonomists have relied on diverse criteria in constructing fruit classifications. However, most fruit classifications fall into three general categories: (1) *traditional/artificial systems*--based on Gray (1877) and widely used in taxonomy texts (Jones and Luchsinger, 1979; Lawrence, 1951; Pool, 1941; Porter, 1967; Rendle, 1930; and Smith, 1977), (2) *morphological systems*--popular in eastern Europe, (Kaden and Kirpicnikow, 1965; Levina, 1961), and (3) *functional systems*--based on mode of dispersal (van der Pijl, 1972). It is beyond the scope of this paper to undertake a detailed comparison and evaluation of these diverse approaches to the classifications of fruits. However, a few comments are appropriate.

Traditional systems emphasize pericarp texture and dehiscence; such systems are obviously artificial and have numerous exceptions since the few fruit types recognized are arbitrary points along a continuum of variation and have no necessary correlation with the morphology of the gynoecium (and associated floral and vegetative structures) from which they were produced. Such terms are useful in descriptive botany (e. g., in floras, keys, and for teaching but lead to errors in phylogenetic/monographic studies due to the arbitrary and non-homologous nature of the recognized categories. (For example, the capsules of Blighia, Casearia, Epidendron, Lecythis, Lyonia, Maytenus, and Oxalis, or the achenes of Bidens, Clematis, Cyperus, and Ostrya, have little in common other than a very superficial external resemblance.) In contrast, botanists using strictly morphological fruit classifications attempt to define terms with morphological/anatomical exactness, stressing a precise ontogenetic connection between flower and fruit structures (Kaden and Kirpicnikow, 1965). Such systems are useful in phylogenetic and monographic studies since recognized fruit types not only show less intra-category variability but also are more likely to represent homologous structures, thus allowing for more meaniful taxonomic comparisons. However, the number of fruit types characterizing the more "fanatical" and detailed morphological systems is often in the hundreds, leading to problems of communication. The usefulness of such schemes is thus much lessened in teaching or floristics. Finally, functional classifications (van der Pijl, 1972), although very appropriate in ecological studies, have not been widely used by taxonomists and are not adequate for conveying the form of the fruit.

In this paper an artificial system of purely descriptive fruit terms is presented, based on the traditional system. A fruit is considered to be a matured pistil (simple or compound) along with fused accessory structures. Simple fruits (those resulting from a single flower) are divided into two categories: first, those formed from a single pistil (simple or compound), and, second, those from several separate pistils (carpels) of a single gynoecium - i. e., "aggregate fruits". The individual fruits of an "aggregate fruit" may be of any of the basic fruit types given in the following key, e. g., follicles in Magnolia, berries in Annona, or drupes in Rubus. The important diversity of fruits seen in tropical regions has been stressed both by applying some definitions more broadly and by adding a few new fruit terms. The use of descriptive terms (e.g., drupacepus schizocarp, winged or samaroid schizocarp, one-seeded fleshy capsule) is also encouraged. The classification is presented by means of an indented key and a series of definitions. Although the system presented herein is admittedly arbitrary, the key and descriptions have proved to be useful in teaching introductory and advanced systematics in both northern temperate and southern tropical Florida. It is hoped that this paper will stimulate further interest both in the terminology of fruits and in the use of fruit characters in the teaching of systematics.

A Key To Fruit Types

A. Fruit the product of several flowers clustered in one mass. . . . . MUTIPLE FRUIT (composed of any of the following fruit types).
A. Fruit (if carpel solitary, or several and fused) or fruits (if carpels several and free) the product of a single flower.
B. Fruit not opening (indehiscent).
C. Fruit fleshy (at least in part).
D. Texture of fruit ± homogeneous (except for seeds), fleshy throughtout. . . . . .BERRY.
D. Texture of fruit heterogeneous.
E. Outer part of fruit firm, hard or leathery. . . . . .BERRY. (Including the hesperidium, pepo, amphisarca.)
E. Outer part of fruit ± soft.
F. Center of fruit with one or more hard "stones" (pyrenes) enclosing seeds. . . . . .DRUPE.
F. Center of fruit with papery or cartilaginous structures enclosing seeds (ovary inferior). . . . . POME.
C. Fruit dry.
G. Fruit with several to many seeds. . . . . .INDEHISCENT POD.
G. Fruit usually only one seeded.
H. Fruit winged. . . . . SAMARA.
H. Fruit wingless.
I. Pericarp (wall of fruit) thick and bony; fruit generally large. . . . . NUT.
I. Pericarp thin; fruit smaller.
J. Pericarp loose and free from the seed . . . . .UTRICLE.
J. Pericarp firm, close-fitting or fused to seed.
K. Pericarp close-fitting, but free from the seed. . . . . . .ACHENE.
K. Pericarp adnate (fused) to the seed . . . . CARYOPSIS.
B. Fruit opening or breaking apart (dehiscent).
L. Ovary rupturing early in development and subsequently withering, the seed(s) maturing externally. . . . . .EARLY DEHISCENT FRUIT.
L. Ovary opening later in development, not withering.
M. Fruit from a single carpel.
N. Fruit dehiscing along a single suture. . . . . FOLLICLE.
N. Fruit dehiscing by two longitudinal sutures, or breaking up by transverse sutures.
O. Sutures longitudinal. . . . . . . LEGUME.
O. Sutures transverse, the fruit breaking into one-seeded segments. . . . . LOMENT.
M. Fruit from a two- to many-carpellate gynoecium.

P. Fruit with a dry/fibrous to leathery or fleshy outer husk that early to tardily breaks apart; center of fruit with hard "stone(s)" enclosing seed(s). . . . . .DEHISCENT DRUPE.

P. Fruit lacking hard "stone(s)" enclosing seed(s); splitting open or into one-seeded segments.

Q. Fruit splitting into one or few-seeded segments (mericarps). . . . . SCHIZOCARP.

Q. Fruit splitting open and releasing seeds.

R. Fruit two-loculate, the two valves splitting away from a persistent thin partition around the rim of which the seeds are attached. . . . . .SILIQUE.

R. Fruit one- to several-loculate, the partition not persistent if the fruit two-loculate. . . . . .CAPSULE. (The more conspicuous kinds are keyed below.)

S. Dehiscence circumscissile (splitting transversely), the top coming off like a lid. . . . . .CIRCUMSCISSILE CAPSULE (PYXIS).

S. Dehiscence not circumscissile.

T. Fruit opening by pores, flaps or teeth.

U. Fruit opening by pores or flaps (often near the top) . . . .PORICIDAL CAPSULE.

U. Fruit opening by a series of apical teeth. . . . . DENTICIDAL CAPSULE.

T. Fruit opening longitudinally or irregularly.

V. Fruit opening irregularly . . ANOMALICIDAL CAPSULE.

V. Fruit opening longitudinally.

W. Valves breaking away from the septa (partitions between the locules). . . . . . . .SEPTIFRAGAL CAPSULE.

W. Valves remaining attached to the septa (at least in part).

X. Fruit splitting at the septa. . . . . . .SEPTICIDAL CAPSULE.

X. Fruit splitting between the septa and into the locules (chambers) of the ovary, or fruit one-locular . . . LOCULICIDAL CAPSULE.

Definitions

Achene.	A ± small, indehiscent, dry fruit with a thin and close-fitting wall surrounding a single seed. (Including the cypsela.) Examples: *Bidens*, *Ceratophyllum*, *Clematis*, *Cyperus*, *Ficus*, *Fragaria*, *Medicago lupulina*, *Ostrya*, *Petiveria*, *Platanus*, *Psoralea lupinellus*, *Rhynchospora*, *Rosa*, *Rumex*, *Sagittaria*, *Trifolium campestre*, *Vernonia*.
Berry.	An indehiscent, fleshy fruit with (one-) few to many seeds. The flesh may be ± homogeneous throughout or the outer part may be hard, firm or leathery; septa are present in some, and the seeds may be arillate or with a sarcotesta. (Including the pepo, hesperidium, amphisarca, and balausta.) Examples: *Aegle*, *Annona*, *Averrhoa*, *Bumelia*, *Cananga*, *Citrus*, *Cucurbita*, *Durio*, *Eugenia*, *Litchi*, *Miconia*, *Musa*, *Opuntia*, *Passiflora*, *Punica*, *Sabal*, *Smilax*, *Solanum*, *Tamarindus*, *Theobroma*, *Vaccinium*, *Vitis*.
Capsule.	A dry to fleshy fruit from a two- to many-carpellate gynoecium which opens (in various ways) to release (one-) few to many seeds. Such fruits may have from one to many locules; if two-loculate then the partition is not persistent. The seeds may be arillate or with a sarcotesta. Examples: *Aesculus*, *Allium*, *Amaranthus* (some), *Argemone*, *Aristolochia*, *Begonia*, *Blighia*, *Campsis*, *Casearia*, *Celosia*, *Clusia*, *Couroupita*, *Echinocystis*, *Epidendrum*, *Eucalyptus*, *Euonymous*, *Geranium*, *Hibiscus*, *Ipomoea*, *Justicia*, *Lachnanthes*, *Lagerstroemia*, *Lecythis*, *Lyonia*, *Maytenus*, *Momordica*, *Myristica*, *Oxalis*, *Pittosporum*, *Portulaca*, *Rhododendron*, *Swietenia*, *Triodanis*, *Viola*.

Caryopsis.	A ± small, indehiscent, dry fruit with a thin wall surrounding and ± fused to a single seed (=Grain). Examples: most Gramineae.
Dehiscent drupe.	A fruit with a dry/fibrous to fleshy or leathery outer husk that early to tardily breaks apart exposing one or more nut-like centers enclosing the seed(s). Examples: *Carya*, *Rhamnus* (some), *Sageretia*, *Scyphosyce*, *Streblus*.
Drupe.	An indehiscent fleshy fruit in which the outer part is ± soft (to occasionally leathery or fibrous) and the center with one or more hard "stones" (pyrenes) enclosing seeds. Examples: *Arctostaphylos*, *Clerodendrum*, *Cocos*, *Cordia*, *Cornus*, *Ilex*, *Juglans*, *Licania*, *Melia*, *Metopium*, *Myrsine*, *Nectandra*, *Orbignya*, *Prunus*, *Psychotria*, *Rubus*, *Scaevola*, *Terminalia*, *Trema*.
Early-dehiscent fruit.	A Fruit in which the ovary ruptures very early in development (due to the emerging seed or seeds) and subsequently withers. Example: *Caulophyllum*.
Follicle.	A dry to fleshy fruit derived from a single carpel which opens along a single longitudinal suture. The seeds may be arillate or with a sarcotesta. Examples: *Akebia*, *Alstonia*, *Aquilegia*, *Asclepias*, *Grevillea*, *Magnolia*, *Nerium*, *Paeonia*, *Sterculia*, *Tabernaemontana* (some), *Zanthoxylum*.
Indehiscent Pod.	An indehiscent ± dry fruit with few to many seeds. Examples: *Adansonia*, *Arachis*, *Bertholletia*, *Cassia fistula*, *Crescentia*, *Kigelia*, *Medicago arabica*, *Thespesia populnea*.
Legume.	A dry to fleshy fruit derived from a single carpel which opens along ± two longitudinal sutures. The seeds may be arillate or with a sarcotesta. Examples: *Abrus*, *Afzelia*, *Daubentonia*, *Delonix*, *Lupinus*, *Pithecellobium*, *Tephrosia*.
Loment.	A dry to fleshy fruit derived from a single carpel which breaks transversely into one-seeded segments. Examples: *Aeschynomene*, *Desmodium*, *Sophora*.
Nut.	A ± large, indehiscent, dry fruit with a thick and bony wall surrounding a single seed. (Including the calybium.) Examples: *Brasenia*,

	Castanea, *Corylus*, *Dipterocarpus*, *Nelumbo*, *Nothofagus*, *Quercus*, *Santalum*, *Shorea*.
Pome.	An indehiscent fleshy fruit in which the outer part is ± soft and the center with papery or cartilaginous structures enclosing seeds. Examples: *Amelanchier*, *Crataegus*, *Pyrus*, and most other Maloideae.
Samara.	A winged, indehiscent, ± dry fruit containing a single seed. Examples: *Ailanthus*, *Betula*, *Casuarina*, *Fraxinus*, *Liriodendron*, *Myroxylon*, *Ptelea*, *Pterogyne*, *Stigmaphyllon*, *Tipuana*, *Ulmus*.
Schizocarp.	A dry to fleshy fruit derived from a two- to many-carpellate gynoecium that splits into one-seeded (or few-seeded) segments (mericarps). If desired, the mericarps may be designated as samara-like, achene-like, drupe-like, etc. Fruits that develop from gynoecia that show postgenital fusion of their apical parts (see Endriss, et al. 1983) are not considered as schizocarps, *e. g.*, *Cynanchum* (follicles), *Sterculia* (follicles), *Ailanthus* (samaras), *Simarouba* (drupes), *Carissa* (berries), *Pterygota* (samaras), see Gandhi & Thomas (1983). Examples: *Acer*, *Apium*, *Cakile*, *Cephalanthus*, *Croton*, *Diodia*, *Erodium*, *Euphorbia*, *Glandularia*, *Gouania*, *Heliconia*, *Heliotropium*, *Lycopus*, *Ochna*, *Oxypolis*, *Pavonia*, *Salvia*, *Sida*.
Silique.	A fruit derived from a two-carpellate gynoecium in which the two valves split away from a persistent partition (around the rim of which the seeds are attached). (Including the Silicle.) Examples: Most Cruciferae, such as: *Arabis*, *Brassica*, *Lepidium*, *Warea*.
Utricle.	A ± small, indehiscent, dry fruit with a thin wall (bladder-like) which is loose and free from a single seed. Examples: *Amaranthus* (some), *Atriplex*, *Chenopodium*, *Lemna*, *Limonium*.

Acknowkedgements

I wish to thank numberous colleagues and students with whom this subject has been discussed.

Literature Cited

Baumann-Bodenheim, M.G. 1954. Prinzipien eines Fruchtsystems der Angiospermen. Ber. Schweiz. Bot. Ges. 64: 94-112.

Egler, F.E. 1943. The fructus and the fruit. Chron. Bot. 7: 391-495.

Endress, P.K., M. Jenny and M.E. Fallen. 1983. Convergent elaboration of apocarpous gynoecia in higher advanced dicotylodons (Sapindales, Malvales, Gentianales). Nord. J. Bot. 3: 293-300.

Gandhi, K.N. and R.D. Thomas, 1983. A note on the classification of fruits. Phytologia. 52: 376.

Gray, A. 1877. Gray's lessons in botany and vegetable physiology. 236 pp. Ivison, Blakman, Taylor and Co., N.Y.

Janchen, E. 1949. Versuch einer zwanglosen Kennzeichnung and Einteilung der Früchte. Österr. Bot. Z. 96: 480-485.

Jones, S.B. and L.E. Luchsinger. 1979. Plant Systematics. 388 pp. McGraw-Hill Book Co., N.Y.

Kaden, N.N. and M.E. Kirpicznikow. 1965. A possible contemporary system of fruit terminology. Taxon 14: 218-223.

Lawrence, G.H.M. 1951. Taxonomy of vascular plants. 823 pp. Macmillan Publ. Co., N.Y.

Levina, R.F. 1961. (Russian title) On the classification and nomenclature of fruits. Bot. Zh. SSSR. 46: 488-495.

Pijl, L. van der. 1972. Principles of dispersal in higher plants. 428 pp. McGraw-Hill Book Co., N.Y.

Pool, R.J. 1941. Flowers and flowering plants. 428 pp. McGraw-Hill, N.Y.

Porter, C.L. 1967. Taxonomy of flowering plants. 472 pp. W.H. Freeman and Co., San Francisco, Cal.

Radford, A.E., W.C. Dickinson, J.R. Massey, and C. Ritchie Bell. 1974. Vascular plant systematics. 891 pp. Harper and Row, Publ., N.Y.

Rendle, A.B. 1930. The classification of flowering plants. Vol. 1 d. 2. 412 pp. Cambridge Univ. Press, Cambridge.

Sattler, R. 1966. Towards a more adequate approach to comparative morphology. Phytomorphology 16: 417-429.

Smith, J.P. 1977. Vascular plant families. 320 pp. Mad River Press, Eureka, Cal.

Stopp, K. 1950. Karpologische Studien I-IV. Abh. math.-nat. Kl. Akad. Wiss. Mainz. 1950(7): 165-210, 495-542.

Winkler, H. 1939. Versuch eines natürlichen Systems der Früchte. Beitr. Biol. Pflanzen 26: 201-220.